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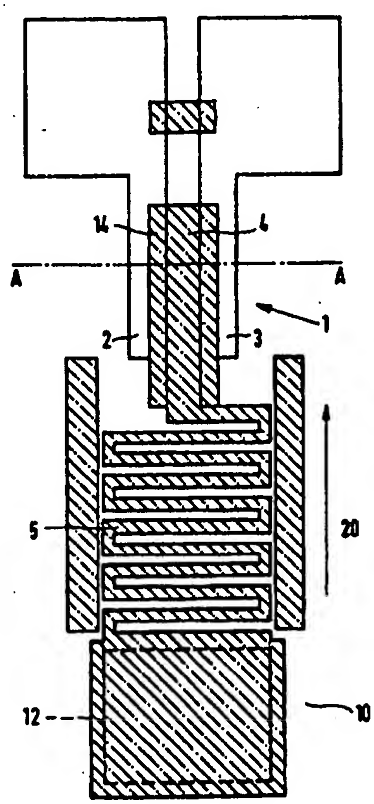
(54) Title: ACCELERATION DETECTION DEVICE

(57) Abstract

The invention relates to a device for measuring accelerations by means of a change in the capacitance value of a capacitor (1) which is provided with two electrode plates (2, 3). According to the invention, the device is characterized in that the capacitor (1) comprises two fixed electrode plates (2, 3) and a dielectric body (4) which can be moved between the electrode plates (2, 3). The device according to the invention thus has two fixed, immovable capacitor plates (2, 3) between which a dielectric body (4) having a certain mass can move under the influence of an acceleration force (20). The distance between the electrode plates (2, 3) is constant owing to the measure according to the invention. The capacitance value changes linearly as a result of a dielectric body (4) being moved far or less far between the capacitor plates (2, 3) so that further processing of the capacitance value is comparatively simple. In addition, there is no risk of short-circuiting of the electrode plates (2, 3).



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Acceleration detection device.

The invention relates to a device for measuring accelerations by means of a change in the capacitance value of a capacitor which is provided with two electrode plates.

Such a device is used for measuring accelerations which are exerted on the device. The term "acceleration" here also includes the force of gravity. Such a device may accordingly be used for measuring accelerations in cars in the case of collisions, but it is also possible with such a sensor to measure the direction of the force of gravity.

US Patent no. 5,326,726 discloses a device of the kind mentioned in the opening paragraph. The known device is a capacitive acceleration transducer in which a movement of a movable electrode relative to a fixed electrode results in a capacitance change or in an electrical contact between the electrodes. An acceleration will cause the movable electrode to move, thus changing the interspacing between the electrodes. The change in interspacing results in a capacitance change which can be related to the acceleration to which the movable electrode was subject.

The known device described has the disadvantage that the measured capacitance and capacitance change is not very well reproducible. Major differences in capacitance value and in the change in capacitance value under the influence of an acceleration may thus exist between devices manufactured by one and the same production process. This means that, for example, read-out electronics must comply with stringent requirements in the known device. Thus, for example, the read-out electronics must cover a comparatively wide measuring range.

The invention has for its object inter alia to counteract the above disadvantage.

According to the invention, the method is for this purpose characterized in that the capacitor comprises two fixed electrode plates and a dielectric body which can be displaced between the electrode plates. The device according to the invention accordingly has

two fixed, immovable capacitor plates between which a dielectric body having a certain mass can move under the influence of an acceleration. The invention is based on the recognition that the capacitance value or capacitance change measured in the known device strongly depends on the positions of the electrode plates. The capacitance value is in fact inversely proportional to the interspacing between the electrode plates. A minor deviation of this interspacing, for example caused by an inaccuracy in the production process or mechanical stresses, will lead to a major variation in the capacitance value. In addition, there is the risk of an undesirable short-circuit between the electrode plates. The measure according to the invention renders the interspacing between the electrode plates constant. The capacitance value now changes linearly as a result of the dielectric body being moved between the capacitor plates. The exact position of the dielectric body in a direction perpendicular to the electrode plates is immaterial. The dielectric body may even make contact with the electrode plates. It is only the degree to which the dielectric body is moved into the space between the plates which causes a change in the capacitance value of the capacitor. There is no risk of the dielectric body short-circuiting the electrode plates.

Preferably, the device is characterized in that the electrode plates and the dielectric body are constructed as comparatively thin layers on a substrate. The electrode plates and the dielectric body are then manufactured by means of techniques which are known, for example, in the field of the manufacture of semiconductor elements. A silicon or glass substrate may be used, for example, as the substrate. Such an embodiment of the device has the advantage that the device can be manufactured with comparatively small dimensions and with a high accuracy by means of standard techniques.

The dielectric body may be provided so as to lie loose between the electrode plates, for example provided with guides and an end stop. It is possible then to measure the position of the dielectric body relative to the electrode plates. When the device is tilted, the dielectric body can slide under the influence of the force of gravity. Thus, for example, the direction of the force of gravity relative to the device can be measured. Preferably, the dielectric body is connected to a spring. The acceleration will then act on the mass of the dielectric body. The acceleration force exerted on the dielectric body will cause the dielectric body to shift and thus load the spring. The acceleration force and the spring force are in equilibrium then. The displacement of the dielectric body between the electrode plates in that case is a measure for the acceleration.

In a preferred embodiment, the dielectric body is provided with an additional mass. The sensitivity of the device to accelerations can be influenced thereby. The

acceleration force is influenced in that the mass of the dielectric body is changed, which will lead to a different displacement of the dielectric body, and thus a different capacitance value of the capacitor, with the spring remaining the same.

The invention will be explained in more detail below by way of example with reference to drawings, in which:

Fig. 1 is a plan view of an embodiment of a device according to the invention,

Fig. 2 is a cross-section taken on the line A-A in Fig. 1 of a device according to the invention, and

Figs. 3 to 6 are cross-sections taken on the line A-A in Fig. 1 of various stages in the manufacture of a device according to the invention.

The Figures are purely diagrammatic and not drawn true to scale. Corresponding parts have generally been given the same reference numerals in the Figures.

Figs. 1 and 2 show an embodiment of a device according to the invention for measuring accelerations by means of a change in the capacitance value of a capacitor 1. Fig. 1 is a plan view and Fig. 2 a cross-section taken on the line A-A in Fig. 1. The capacitor 1 is provided with two electrode plates 2, 3. According to the invention, the capacitor 1 comprises two fixed electrode plates 2, 3 and a dielectric body 4 which can be moved between the electrode plates. The device according to the invention thus has two fixed, immovable capacitor plates 2, 3 between which a dielectric body 4 having a certain mass can move under the influence of an acceleration 20.

The dielectric body 4 is connected to a spring 5 in the present example. When an acceleration force 20 is exerted on the mass of the dielectric body 4, the dielectric body 4 will slide between the electrode plates 2, 3 and load the spring 5. The acceleration force and the spring force will then reach an equilibrium (see Fig. 1). The degree to which the dielectric body 4 has moved to between the electrode plates 2, 3 then is a measure for the acceleration which obtains.

This first embodiment of the device is manufactured by techniques which are known from the manufacture of semiconductor elements (IC technology). Figs. 3 to 6 show stages in the manufacture of the device. The electrode plates 2, 3 and the dielectric

body 4 are constructed as comparatively thin layers on a substrate 10.

The manufacture of this embodiment of the device starts with a glass substrate 10. A 2 μm thick TiPtAu layer is provided on this glass substrate 10 by a standard sputtering technique and patterned by standard photolithographic and etching techniques. The electrode plates 2, 3 are created thereby (see Fig. 3). A so-called sacrificial layer 11 of 0.5 μm thick silicon oxide is provided over the electrode plates 2, 3 by a CVD (Chemical Vapor Deposition) process (see Fig. 4). The sacrificial layer 11 is given a hole 12 down to the substrate (the location of the hole 12 is shown in the plan view of Fig. 1) by means of standard photolithographic and etching techniques. A layer 4 of a dielectric material is provided over the sacrificial layer 11 then, in this example a 1 μm thick layer of PZT (lead-zirconium-titanate, see Fig. 5). The layer 4 is provided in a standard manner by a sol-gel technique. This layer is subsequently fired at 700 °C in O_2 and patterned by means of photolithographic and etching techniques so as to create the dielectric body 4 and the spring 5 (see Fig. 6). In this example, the dielectric body is provided with an additional mass 14. The sensitivity of the device to accelerations can be influenced in this manner. A change in the mass of the dielectric body 4 influences the acceleration force, which will lead to a different displacement with the spring 5 remaining the same. The additional mass 14 is provided in this example by retaining a certain overlap over the electrode plates 2, 3 during etching of the layer 12. The sacrificial layer 11 is now removed by an isotropic etching technique with HF. The dielectric body 4 with the additional mass 14 and the spring 5 then become freely movable. The spring is connected to the substrate through the hole 12 only. Such an embodiment of the device has the advantage that the device can be manufactured with comparatively small dimensions and with a high accuracy by standard techniques.

The device thus obtained can be manufactured to a high accuracy, while manufacturing tolerances are narrow.

The invention is not limited to the embodiment described above, but variations are possible within the scope of the invention. The device may alternatively be used for indicating a position. The device is provided with several capacitors in that case, comprising fixed electrode plates between which there is a common space. The dielectric body is present in this space and can move freely therein, the position being derived from the position of the dielectric body with respect to the electrode plates of the different capacitors. It is thus possible to manufacture a device according to the invention in that a dielectric body is provided on a spring between two conductive surfaces, for example silicon slices. In the

example, the dielectric body is linearly moved between the electrode plates. It is quite possible, however, for this body to perform a rotary movement between the electrode plates. Alternatively, the electrode plates may very well be manufactured from a material other than gold, for example a metal such as aluminum, chromium, copper, tungsten, or silicides, or a conductive monocrystalline, polycrystalline, or non-crystalline semiconductor material such as silicon.

Furthermore, the sacrificial layer may be manufactured from a material other than silicon oxide. It is important that the material of the sacrificial layer should be capable of selective etching with respect to the material of the electrode plates and the material of the dielectric body. Such combinations are known.

A lateral capacitor is manufactured in the embodiment, i.e. the direction from the one electrode plate via the dielectric body to the other electrode plate runs parallel to a main surface of the substrate. It is alternatively possible for this direction to be transverse, i.e. perpendicular to the substrate. In that case, first a first, subjacent electrode plate is manufactured on the substrate, then a sacrificial layer, the dielectric body, a second sacrificial layer, and finally the second, upper electrode plate, whereupon the sacrificial layers are removed.

It is also possible for the two electrode plates to be made from different materials. A transverse device may be realized in a simple manner, for example, in that a conductive silicon substrate is used as the first electrode plate, while the second, upper electrode is made from metal.

The electrode plates and/or the dielectric body may be provided with holes or slots for facilitating the removal of the sacrificial layer by etching.
In the present example, the additional mass was made from the same material as the dielectric body 4. It is also possible to manufacture the additional mass from a different material than the dielectric material, for example through the provision of a further layer and patterning of this layer.

The device may be manufactured as a stand-alone device. It is alternatively possible for the device to be manufactured in the back end of a semiconductor manufacturing process. The metal and dielectric layers available in that process are utilized in that case. The substrate used for the device then comprises, for example, semiconductor devices which serve for measuring the capacitance value of the capacitor and for further processing of this value.

The example described relates to a device manufactured by semiconductor

manufacturing techniques. Although this is to be preferred on account of the manufacturing accuracy and reproducibility thereof, it implies by no means that a device according to the invention can be manufactured only by these techniques.

More details on known techniques and materials can be found in handbooks such as S.M. Sze: "VLSI Technology", Mc-Graw-Hill Book Company, and S. Wolf: "Silicon Processing for the VLSI Era", vol. 1, 2, Lattice Press.

Claims:

1. A device for measuring accelerations by means of a change in the capacitance value of a capacitor which is provided with two electrode plates, characterized in that the capacitor comprises two fixed electrode plates and a dielectric body which can be displaced between the electrode plates.

2. A device as claimed in Claim 1, characterized in that the electrode plates and the dielectric body are constructed as comparatively thin layers on a substrate.

3. A device as claimed in any one of the preceding Claims, characterized in that the dielectric body is connected to a spring.

4. A device as claimed in Claim 3, characterized in that the dielectric body is provided with an additional mass.

5. A device as claimed in any one of the preceding Claims, characterized in that the dielectric body comprises a material with a dielectric constant higher than 800.

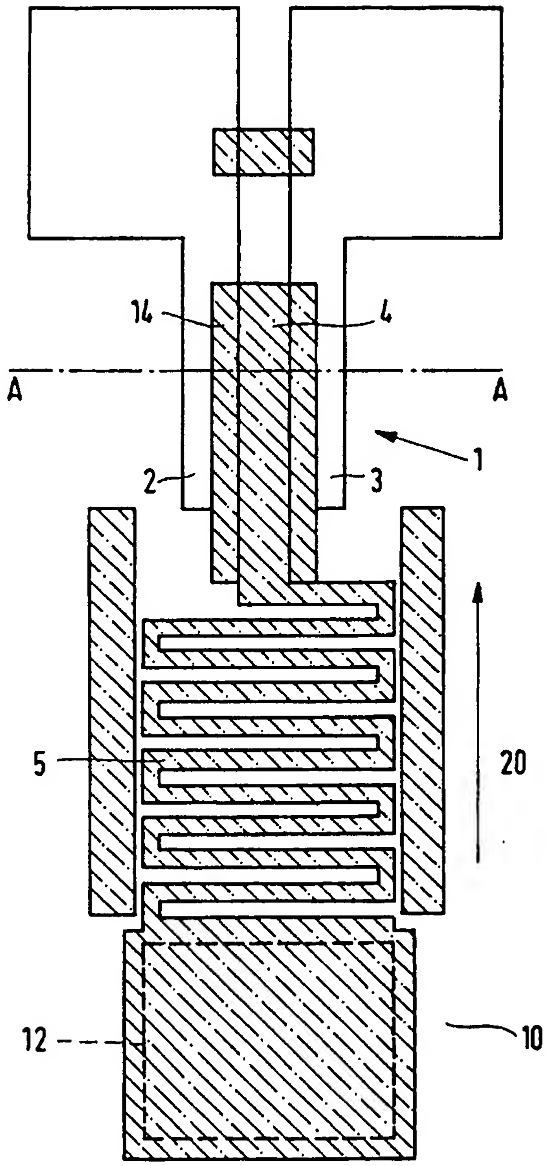

FIG.1

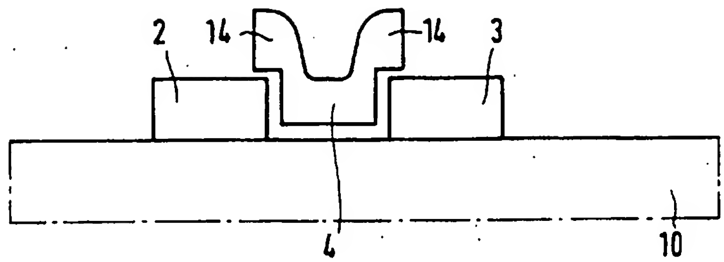

FIG.2

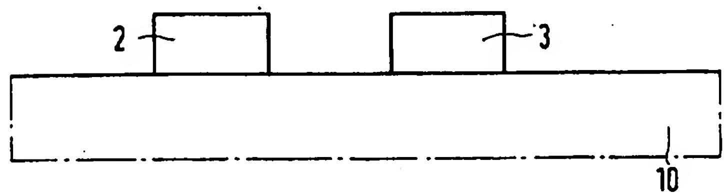

FIG.3

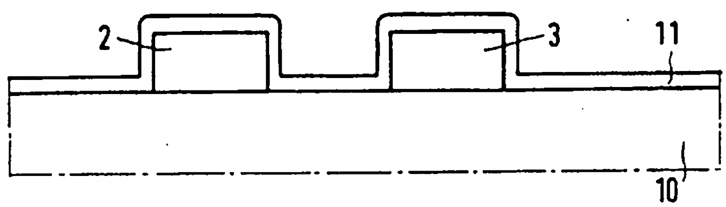

FIG.4

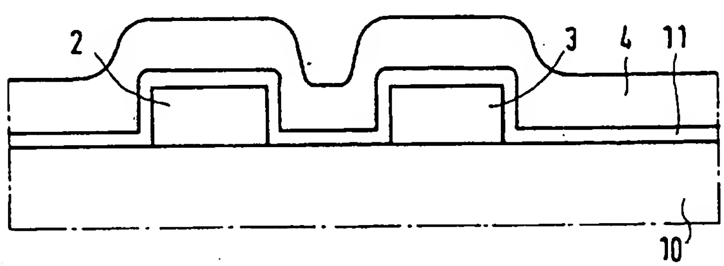

FIG.5

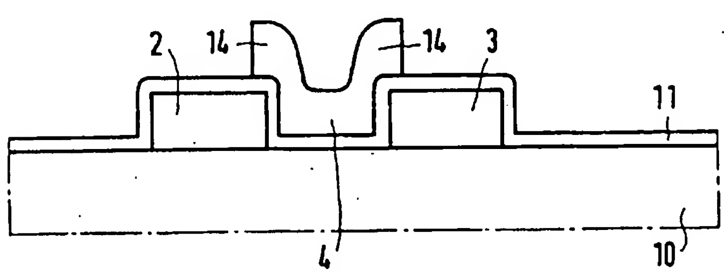

FIG.6